ELECTRO-ACOUSTIC TRANSDUCER DIAPHRAGM WITH INTEGRATED STRUCTURAL FEATURES, AND RELATED SYSTEMS AND METHODS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] The present application is a divisional of U.S. patent application Ser. No. 16/149,307, entitled "Electro-Acoustic Transducer Diaphragm with Integrated Structural Features, and Related Systems and Methods," filed Oct. 2, 2018, which claims the benefit of U.S. Provisional Patent Application Ser. No. 62/725,103, entitled "Electro-Acoustic Transducer Diaphragm with Integrated Structural Features, and Related Systems and Methods," filed Aug. 30, 2018, each of which is hereby incorporated by reference in its entirety for all purposes.

FIELD

[0002] This application and related subject matter (collectively referred to as the "disclosure") generally concern electro-acoustic transducers, and related systems and methods.

BACKGROUND INFORMATION

[0003] Electronic devices can include one or more electro-acoustic transducers to emit sound. Given size constraints, some electronic devices incorporate electro-acoustic transducers configured as so-called "micro-speakers." Examples of micro-speakers include a loudspeaker transducer found within an earphone, a headphone, a smart-phone, or other similar compact electronic device, such as, for example, a wearable electronic device, a portable time-piece, or a tablet-, notebook-, or laptop-computer.

SUMMARY

[0004] In some respects, concepts disclosed herein broadly concern electro-acoustic transducers, and more particularly, but not exclusively, loudspeaker transducers. More particularly, but not exclusively, this disclosure pertains to loudspeakers that include a diaphragm having integrated structural features, such as, for example, a pedestal suitable for lap-joining with a movable portion of an electric driver (e.g., a voice coil). As but one other illustrative example, a disclosed loudspeaker diaphragm can include one or more supplemental stiffeners, as to modify a break-up frequency mode of the diaphragm.

[0005] Some disclosed transducers include a diaphragm having integrated structural features that improve a physical robustness of the transducer. For example, some disclosed structures are suitable for improving a physical connection with a drive element. As well, some disclosed structural features can improve a physical robustness of the transducer and/or alleviate manufacturing defects. Such structural features can modify a break-up frequency, e.g., by moving a break-up frequency mode outside an audible frequency band. As a consequence, some disclosed electro-acoustic transducers can be driven through larger excursions and with more force than conventional electro-acoustic transducers, providing improved fidelity and louder playback compared to prior electro-acoustic transducers.

[0006] According to a first aspect, an electro-acoustic transducer includes an acoustic diaphragm defining a first major surface and an opposed second major surface. A pedestal extends transversely from the second major surface. The acoustic diaphragm and the pedestal form a unitary construct. The electro-acoustic transducer also includes a drive element. The pedestal and the drive element are positioned in an overlapping registration with each other.

[0007] The pedestal can define an outer surface and the voice-coil can define a corresponding inner surface. The electro-acoustic transducer can further include an adhesively bonded lap joint between the outer surface of the pedestal and the inner surface of the voice-coil.

[0008] The pedestal can define an inner surface and the voice-coil can define a corresponding outer surface. The electro-acoustic transducer can further include an adhesively bonded lap joint between the inner surface of the pedestal and the outer surface of the voice-coil.

[0009] The drive element can have a plurality of layers of an electrically conductive filament. The overlapping registration between the drive element and the pedestal can include an overlapping relationship between the pedestal and the plurality of layers of the electrically conductive filament. In some instances, the drive element extends from a proximal end positioned adjacent the acoustic diaphragm to a distal end spaced apart from the acoustic diaphragm. The plurality of layers in overlapping relationship with the pedestal can include a first plurality of layers positioned adjacent the proximal end of the drive element. The drive element can further include a second plurality of layers of the electrically conductive filament.

[0010] The voice-coil of some disclosed electro-acoustic transducers can extend longitudinally from a proximal end positioned adjacent the acoustic diaphragm to a distal end spaced apart from the acoustic diaphragm. The overlapping registration between the voice-coil and the pedestal can include an overlapping relationship between the pedestal and the proximal end of the voice-coil.

[0011] The overlapping registration between the voice-coil and the pedestal can further include an adhesive bond between the pedestal and the voice-coil.

[0012] According to another aspect, an electro-acoustic transducer includes an acoustic diaphragm defining a first major surface and an opposed second major surface. Each of the first major surface and the opposed second major surface defines a corresponding major axis and a minor axis. Each respective major axis is longer than the corresponding minor axis. The electro-acoustic transducer includes a pedestal extending transversely from the second major surface, and a drive element. The electro-acoustic transducer also includes an adhesively bonded lap joint between the drive element and the pedestal.

[0013] The acoustic diaphragm and the pedestal can form a unitary construct.

[0014] The acoustic diaphragm can define an outer periphery. The pedestal can extend from the second major surface at position adjacent the outer periphery.

[0015] The acoustic diaphragm can define an outer periphery and the lap joint can be positioned inwardly of the outer periphery.

[0016] The electro-acoustic transducer can further include a stiffener extending from the first major surface and along the acoustic diaphragm toward the outer periphery. Such a stiffener can be integrally formed with the diaphragm. Such a stiffener can include an elongate rib having a longitudinal axis and defining a cross-sectional area. The cross-sectional